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**INDIGENOUS ENVIRONMENTAL KNOWLEDGE:
PAST CASES AND FUTURE PROSPECTS**

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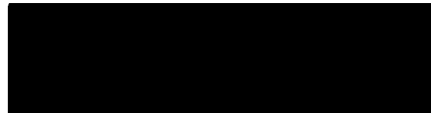
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Indigenous Knowledge: Past Cases and Future Prospects

Thesis Directed by Professor and Chair Stephen Koester

ABSTRACT

Indigenous Environmental Knowledge defined as, a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (human and non-human animals and plants) with one another and with their physical environment, has a great potential to inform western science in the area of climate change. This thesis presents work that has been conducted in the arctic and sub-arctic with Indigenous Knowledge. Work conducted in Saint Mary's, Alaska is also presented. This project utilized semi-structured interviews with Elders and hunters' in order to study the effects of climate change in the subarctic. Finally, there is a discussion of future research proposed to be undertaken in the Yukon River Basin to further study climate change and Indigenous Knowledge.

This abstract accurately represents the content of the candidate's thesis. I recommend its publication.

Signed



Stephen Koester

DEDICATION

I dedicate this thesis to all of my friends and family who have helped me get here. I especially want to dedicate this to my husband who has supported and helped me every step of the way, from my undergraduate work through the writing of this paper. My mother without whose help with my children while I was at school or in Alaska and reading my work for as long as I can remember I would not have been able to come this far in my education. I also dedicate this to my children who have often heard that I had homework to do when I wanted to be playing with them, but to whom I also hope see with this document what hard work and perseverance can get you.

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CHAPTER 1

INDIGENOUS KNOWLEDGE

Introduction

Indigenous Knowledge has taken on greater importance in scholarly research in recent years. Indigenous Knowledge also referred to as Traditional or local Knowledge generally refers to a collection of knowledge passed down through generations that is culturally relevant and allows a group of people to subsist in their environment. Throughout this paper the term Indigenous Knowledge will be used as the terms Traditional or Local Knowledge do not always capture the whole picture. For instance, Traditional may be inferred to mean static and in the past whereas Indigenous Knowledge is dynamic and relevant in the present (Huntington & Fox 2005). Additionally, Local Knowledge may or may not refer to locals who are also Indigenous failing to capture the sense of continuity and the practice of building on what was learned by previous generations (Huntington & Fox 2005).

The first important contributions utilizing Indigenous Knowledge in scholarly research were made by anthropologists. The work of anthropologists of creating ethnographies of otherwise unknown groups of peoples illuminated the fact that Indigenous Peoples know far more about their environment and the ecology therein,

than outsiders do. In a rapidly changing and developing world it has become clear in recent years to researchers from other disciplines that the best way to understand and successfully preserve endangered eco-systems or develop Indigenous lands is through the inclusion of Indigenous Knowledge. The breadth of research conducted in recent years with the inclusion of Indigenous Knowledge is evident in a quick search of the literature. As stated by Warren et al. (1993:2) and quoted by Agrawl (1995),

“Ten years ago, most of the academics working in the area of Indigenous Knowledge represented anthropology, development sociology, and geography. Today...important contributions are also being made in the fields of ecology, soil science, veterinary medicine, forestry, human health, aquatic science, botany, zoology, agronomy, agricultural economics, rural sociology, mathematics, ...fisheries, range management, information science, wildlife management, and water resource management.”

Research concerned with Indigenous Knowledge in the arctic and subarctic is situated within a larger body of research that has been conducted worldwide. This chapter will describe Indigenous Knowledge studies that have taken place in the arctic and subarctic. It will begin with examples of how Indigenous Environmental Knowledge may be used as a foundation for co-management of resources and end with a description of the important contributions Indigenous Peoples are making to further our understanding of climate change in the arctic and subarctic.

Indigenous Environmental Knowledge

Indigenous Knowledge has made important contributions to a greater understanding of ecological processes that were otherwise poorly researched in the

arctic and subarctic. One such example comes from the tragedy of the Exxon Valdez oil spill. In the period after the spill ecologists wished to know how animal populations were responding to the changing ecological conditions brought about by the spill. In the case of the herring fish population scientists had little or no data from before the spill from which to compare. Huntington (1989) was asked to work with the Indigenous Peoples of this area in order to create a baseline of information about the herring population prior to the spill. Indigenous Knowledge of the herring population was gathered and used to help ecologists understand how the herring population was reacting in the period following the oil spill.

More recently Fienup-Riordan (1999) helped biologists to understand the black brant geese population in southwestern coastal Alaska. Fienup-Riordan has worked extensively with the Yup'ik people of this area (1994; 1999) and was asked in 1992 by biologist Jim Sedinger of the University of Alaska Fairbanks (UAF) to carry out ethnographic research documenting the Yup'ik understanding of the effects of storm surges and changing coastal ecology on the breeding habits of black brant geese. Throughout the fall and winter of 1994-95 researchers carried out twenty-nine interviews with village Elders in five communities. These interviews provided detailed accounts of Yup'ik Elders understanding of how, why, when, and where geese feed, nest, and raise their young and how geese are affected by coastal flooding.

Similar research was conducted on the island of St. Lawrence in Alaska to understand the bowhead whale population of the Bering Sea. Although considerable

research has been conducted concerning the bowhead whale in the Chukchi and Beaufort seas relatively little research has taken place in the northern Bering Sea (Noongwook et al. 2007). This research was initiated due to concerns of the International Whaling Commission (IWC) that more than one stock of bowhead whales was present in the Bering Sea. This concern caused the IWC to hesitate in granting a renewal of a five-year block hunting quota under which Alaska Eskimo whalers hunt.

Therefore, a study was conducted in which traditional knowledge of bowhead whales held by Yup'ik whalers was documented in the communities of Gambell and Savoonga on St. Lawrence Island. The goal of the research was to record local understanding of important and otherwise unavailable information about the bowhead whales in the northern Bering Sea (Noongwook et al. 2007). Of most importance were the issues of: (1) the migratory patterns and seasonal distributions of bowhead whales near St. Lawrence Island, (2) the possibility of distinct stocks or sub-stocks in the area, and (3) changes over time in bowhead abundance and distribution. The approach of this study allowed St. Lawrence Island Yup'ik whalers to contribute to the broader scientific literature about bowhead whales (Noongwook et al. 2007).

Traditional knowledge of bowhead whale populations was gathered through semi-directive interviews, mostly in group settings with whaling captains and whalers. The research team was multidisciplinary, including a local leader and whaling captain (Noongwook), a biologist specializing in bowhead whales, and a

researcher with extensive in traditional knowledge studies. This allowed for the group interview sessions to become a dialogue as opposed as a one-way transmission of knowledge from Yup'ik whaler to researcher. Information from bowhead whale studies in other areas was shared with the Yup'ik whalers by the biologist, which helped to create a sense of shared enterprise between the researchers and interview participants.

Although this study was brief, taking place the last week of January 2006, and is therefore not exhaustive in bowhead whale data for the northern Bering Sea important contributions were made to the study of bowhead whales in this area and the foundation was laid for further work. The research concluded that in the Yup'ik of St. Lawrence Island believe the bowhead whales of the northern Bering Sea are thriving. They did note that environmental change has shifted the distribution, timing, and availability to whalers, but this did not appear to be affecting the health of the whales. In fact the population was said to be healthy and increasing with the observation of more young whales than in the past by the Yup'ik whalers. Information collected in this study is consistent with current understanding of bowhead whale population trends for the northern Bering Sea.

The kind of Indigenous Environmental Knowledge collected in the previous studies lays the foundation for the co-management of resources. Co-management can be described as a process of managing natural resources in which the local government, or other regulatory agency, works with the Indigenous Peoples who rely

on those resources so that both parties needs are met. This is of course an idealized scenario and co-management does not always work in favor of the Indigenous Peoples. However, in the case of the bowhead whales and the IWC's concerns about the Bering Sea population Indigenous Peoples were able to work with researchers to address the regulatory agency's concerns and thereby work with the agency to manage the resource of bowhead whales.

The Beverly and Kaminuriak Caribou Management Board is often cited as an example of successful co-management (Osherenko 1988; Cizek 1990; Usher 1993). The Caribou Management Board is an advisory board for the management of the Beverly and Kaminuriak caribou herds and began in 1982. These herds are a resource shared among Inuit and Dene hunting communities and the range of the herd encompasses more than one governmental jurisdiction. The board functions as a sounding board for government initiatives and an early warning system for user concerns, as well as an orderly way to deal with them.

Climate Change

Climate change is a topic about which indigenous peoples have a great deal to share with the world. Huntington, Fox 2005

The Inuit of Northern Alaska and Canada have become participants in a great amount of work revolving around climate change. The Inuit's detailed understanding of their environment has made them key partners in furthering the understanding of

the changing climate. Gearheard (Fox 2002; Gearheard 2006; 2009) has worked extensively with the Inuit of Nunavut Canada to understand how their Knowledge of the environment can add to sciences understanding of climate change. Gearheard's (Fox 2002) work with the Inuit began when she was completing her dissertation work at the University of Colorado at Boulder in 1995. Gearheard spent months living with the Inuit of Nunavut, Canada, utilizing participant observation and intensive interviewing methods to understand the changes in the climate that were being experienced by the Inuit in that area. Her research showed that the weather had become less predictable and there had been an increase in wind. The Elders of Nunavut told her that in the past they had always been able to predict the weather, sometimes for many days out, with considerable accuracy. The increase of wind was affecting the Inuit because it changed the composition of the snow making it difficult to construct the traditional igloo snow shelters they used when hunting.

Unpredictable weather combined with an inability to construct proper hunting shelters becomes an issue of safety for the Inuit. Gearheard (2009) recently worked with the Inuit of Nunavut, Canada to link their knowledge with meteorological station observations in the area to understand changing wind patterns.

The most recent work revolving around Indigenous Environmental Knowledge is currently being conducted by Igor Krupnik (2009) an anthropologist with the Arctic Studies Center of the Smithsonian National Museum of Natural History. The task of this study, "...is to explore how data generated by polar residents can be matched with the observations and models used by polar scientists." (Allison et al. 2007 as

cited in Krupnik et al. 2009). Krupnik (2009) states their goal further, “to investigate the cultural, historical, and social processes that shape the sustainability of circumpolar human societies, and to identify their unique contributions to global cultural diversity and citizenship.” In addition to documenting what Indigenous Peoples already know about the environment, the researchers in this study are training Indigenous Peoples to document changes in the environment with western scientific tools so that Indigenous residents and scientists may be colleagues and collaborators in the process of understanding climate change.

Conclusion

Indigenous Environmental Knowledge and the holders of this knowledge have important contributions to make to our overall understanding of ecological processes and climate change, as evidenced by the discussion above. Through their reliance and use of the environment Indigenous Peoples have an intimate understanding of processes that biologists are just beginning to understand. By working together Indigenous Peoples and scientists can both have a greater understanding of the environment and how it may be changing. The following chapter will describe an exploratory project carried out in Saint Mary's, Alaska with the goal of linking Yup'ik Knowledge with scientific knowledge on the issue of climate change.

CHAPTER 2

A SYNTHESIS OF INDIGENOUS ENVIRONMENTAL KNOWLEDGE AND SCIENTIFIC FINDINGS: SAINT MARY'S ALASKA

Ecosystems sustain themselves in a dynamic balance based on cycles and fluctuations, which are nonlinear processes... Ecological awareness, then, will arise only when we combine our rational knowledge with an intuition for the nonlinear nature of our environment. Such intuitive wisdom is characteristic of traditional, non-literate cultures, especially of American Indian cultures, in which life was organized around a highly refined awareness of the environment.
Capra 1982:4

Introduction

As evidenced by the previous discussion, there has been a recent surge in both academic and scientific interest in Indigenous Environmental Knowledge (IEK) (also referred to as Traditional Ecological Knowledge or TEK) and how it can contribute to our understanding of climate change in the arctic (Krupnik, Lang, Miller, 2009; Berkes, Jolly, 2001). Owing to the continuous settlement and subsistence patterns of Indigenous Peoples of the arctic and subarctic, combined with the 'highly refined awareness of the environment', of which Capra speaks, IEK has a great potential to inform western scientists on changes taking place in the arctic and subarctic, thereby increasing understanding of the complex ecological and societal impacts of climate change. IEK will be used throughout this paper to describe a cumulative body of environmental knowledge and beliefs, handed down through generations by cultural transmission, focusing on the relationship with the physical environments of land, air,

water, and vegetation, as the physical environment often takes on a sentient role in Indigenous cultures (Fienup-Riordan, 1999).

The Indigenous Peoples of Interior Alaska are well-suited to a study of this kind because of the unique circumstances surrounding their contact with the west. Unlike the resettlements of Indigenous Nations that took place in the contiguous United States, the Indigenous Nations of the Interior of Alaska were not forcibly relocated, thus preserving continuous settlement and subsistence patterns allowing their knowledge of their environment to continue to flourish into modern times. Furthermore, significant Euro-American settlement did not occur in Western Alaska until the end of the 19th century due to a lack of commercially valuable resources (Fienup-Riordan 1994).

The residents of Saint Mary's, Alaska, have been living their traditional subsistence way of life since time immemorial, with relatively little change until recent years; this is true of many other native villages of Alaska as well. Although some of their rituals have been lost over the years due to prohibitions imposed from outside governments, their subsistence way of life and relationship with the land has altered very little. Today about seventy-five percent of the diet of Indigenous residents of Saint Mary's comes from the land, hunted or gathered in the traditional manner (personal communication, Pat Beans Jr. 5/1/2009).

Objectives

Much recent work in the area of IEK and climate change has concentrated on the coastal arctic communities of Alaska, Canada, and Greenland (Fienup-Riordan, 1999; Krupnik, Lang, Miller 2009; Fox 2002). Very little attention has been given to inland communities of the arctic and subarctic and no literature has been published with a focus on IEK and climate change conducted in the river basins of the arctic and subarctic. This exploratory study focuses on filling the literary gap and examining what IEK can tell us about climate change in the interior subarctic portion of the Yukon River Basin (YRB) in Alaska.

The objectives of this exploratory study were four fold:

- To understand the perception of climate change impacts in the Lower YRB of Interior Alaska.
- To understand what affects climate change may be having on the local culture.
- To gain a more comprehensive understanding of climate change in the arctic and subarctic region through the synthesis of IEK and Western science.
- To assess the feasibility of expanding the scope of the study area to include Indigenous Peoples across the entire YRB.

Study Area

The state of Alaska has little more than a skeleton road system, Saint Mary's and many other Indigenous communities in the region, are very remote with no access to the primary road system, relying on travel via airplanes, riverboats, dog teams and snow machines. Saint Mary's is located within the YRB in the Southwestern region of Alaska (Figure 1). It lies on the north bank of the Andreafsky River, five miles from its confluence with the Yukon River. The villages of Saint Mary's and Andreafsky lie within the city limits of Saint Mary's. Andreafsky, named for the Andrea family whom settled on the River and established a Russian Orthodox Church, was founded in 1899 as a supply depot and winter headquarters for the Northern Commercial Company's riverboat fleet. In 1967, Saint Mary's incorporated as a city, although residents of Andreafsky chose to remain a separate community until 1980 when Andreafsky also incorporated.

Saint Mary's is a Yup'ik (plural Yupiit) community consisting of 87.6% Alaska Native or part Native people that maintains a subsistence lifestyle of fishing, hunting, and gathering. Within Saint Mary's are two federally-recognized tribes the Algaaciq Tribal Government and the Yupiit of Andreafsky. Yup'ik is the self-designation of the Indigenous Peoples of western Alaska commonly referred to as Eskimos throughout the rest of the country. The word Yup'ik is derived from their word for person (yuk) plus the post base – pik, which translates to real or genuine (Fienup-Riordan 1994), thus the Yupiit believe themselves to be genuine people.

The Yup'ik

The Yupiit are members of the larger family of Eskimo cultures, extending from Prince William Sound on the Pacific coast of Alaska to Bering Strait, and from there six thousand miles north and east along Canada's Arctic coast and into Labrador and Greenland (Fienup-Riordan 1994). Within that family however, they are members of the Yup'ik speaking not Inuit/Inupiaq speaking branch (Fienup-Riordan 1994).

Extensive ethnographic work has been done with the Yup'ik of Southwestern Alaska by anthropologist Anne Fienup-Riordan. She began her work in 1976 on Nelson Island utilizing the traditional ethnographic method of participant observation and published the results in her first book, *The Nelson Island Eskimos* (1983). She has been involved in collaborative work with the Yupiit of Southwestern Alaska including, the Association of Village Council Presidents, the Yupiit Nation, the Toksook Bay Traditional Council, and most recently for the Coastal-Yukon Mayors' Association and the Anchorage Museum of History and Art in their efforts to organize the Yup'ik mask exhibit "Agayuliyararput: Our Way of Making Prayer".

The Indigenous Peoples of Western Alaska were most influenced by the missionaries that began moving into their area in 1845. The most significant changes began with the influenza epidemic that arrived with the annual supply vessels in 1900. Over the following three months the native population was cut in half, accompanied by a sharp increase in the white population (Fienup-Riordan 1994). Catholic missionaries in these areas established schools and orphanages to care for

ldren whose parents died in the epidemic. These schools undoubtedly had an impact
he continuation of traditional Yup'ik customs after the epidemic.

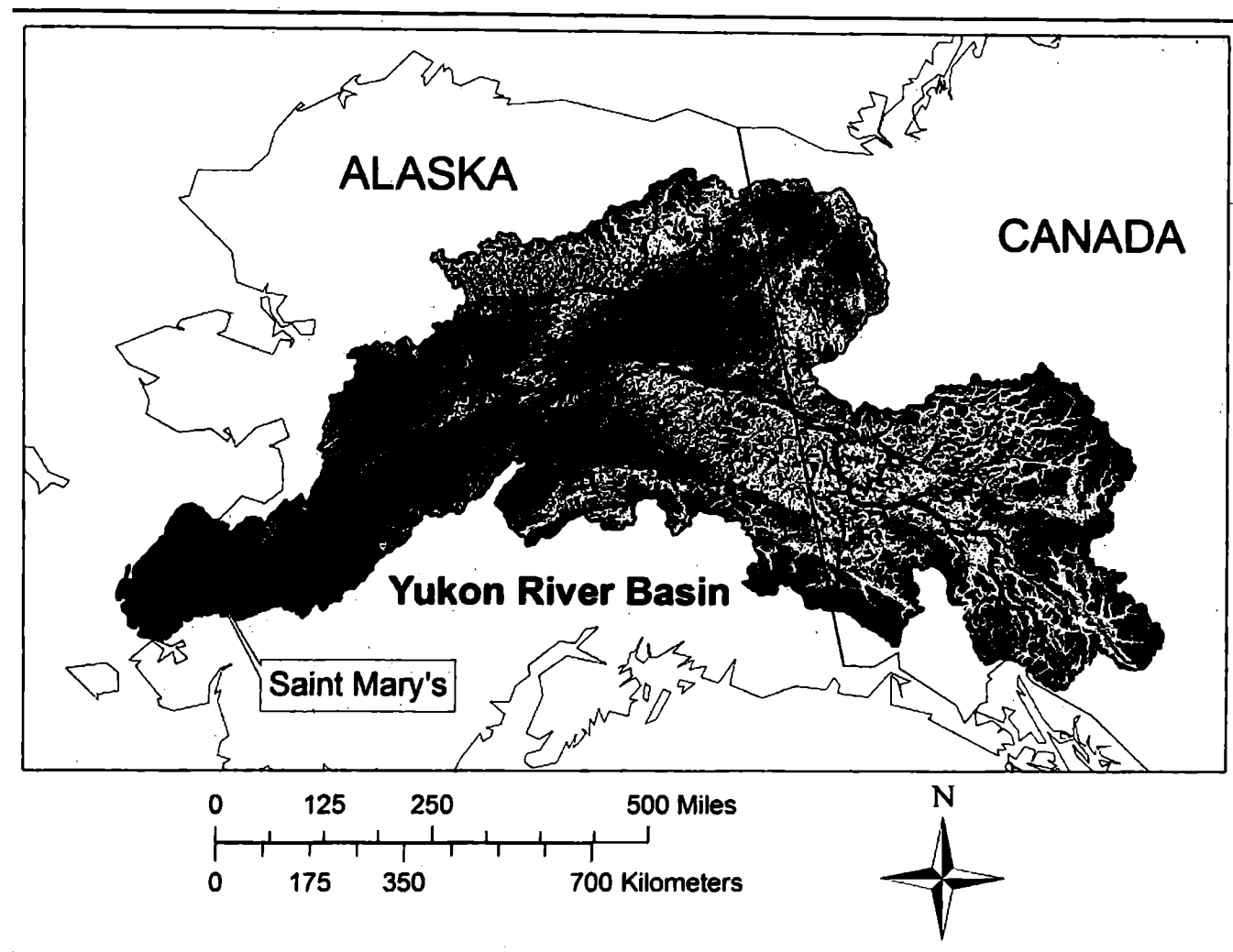


Figure 1 Saint Mary's, Alaska within the Yukon River Basin

In her book, *Boundaries and Passages: Rule and Ritual in Yup'ik Eskimo*
dition (1994), she describes the Yup'ik worldview as one of an undifferentiated
verse. In contrast to the worldview we in the western world have inherited from

Hobbes and others, which assumes that humans are first and foremost individuals, only brought to unity through the fulfillment of self-interest, the Yup'ik believe that individuals are formed from a unity of undifferentiated persons (human and nonhuman animals) through rule and ritual, which maintains the boundaries and passages between humans and nonhuman animals, as well as the spiritual and material worlds. "A paradigm fundamentally different from that of most western peoples organized Eskimo cosmology. It was originally founded on the assumption of an undifferentiated universe, wherein human attention to the rules was an act of participation necessary both to create difference and maintain connections." (Fienup-Riordan 1994). Fienup-Riordan (1994) elaborates on this saying, "The ritual process creates that passages between worlds as cultural rules set the boundaries between them. Food sharing and gift giving constitute the core of Yup'ik social life."

Approach

IEK has been promoted by a wide range of academic disciplines for its ability to improve scientific research and management through more and sometimes better information than that gained through western science (Huntington 2000). Indigenous Knowledge has gained appreciation through a growing recognition that the Indigenous Peoples the world over developed sustainable environmental knowledge and practices that can be used to address problems that face global society (McGregor 2004). This study assumes that Western Science and Indigenous Knowledge are complementary in their strengths and weaknesses and seeks to overcome the false dichotomy that these two ways of knowing are in opposition.

Indigenous Environmental Knowledge and Western Environmental Science are both based on observations made by people and often make use of the same tools and methods to reach their conclusions. Western science is based on the scientific method of making an observation, forming a hypothesis, testing that hypothesis through experimentation, and analyzing the findings. Indigenous peoples have used this same basic approach since time immemorial though they have not given this process a name as has western science. As Bielawski (1995) states in regards to the Yupiit's northern neighbors, the Inuit, "Inuit knowledge is consensual, replicable, generalizable, incorporating, and to some extent experimental and predictive." Moreover, Kawagley (1995), whom was raised in a Yup'ik community, concurs with Bielawski's statement, "'Predictions' were made on the coming winter's weather, plentifulness or scarcity of fish for the following summer, the coming summer's berries and where they will be most plentiful, and so on. This was done by observing and reading the sign-makers of nature, and it reflects the power of the thinking Native mind. Predictions were made based on observable phenomena." Documenting Indigenous Knowledge of the subarctic leads us closer to understanding the observable phenomena of climate change and the affect it is having on the people and ecology; an area that may not be otherwise captured through western scientific methods.

Methodology

Observations and perceptions of climate change were collected through semi-structured interviews with Elders and hunters Indigenous to Alaska in the city of

Saint Mary's and the adjacent village of Pitka's Point. The city of Saint Mary's was chosen for this study based on the recommendation of a colleague from the Yukon River Inter-Tribal Watershed Council (YRITWC) and communication with a researcher from Alaska's Department of Fish and Game. In addition, Saint Mary's was chosen for logistical reasons; the city has their own airport and hotel, a rarity in the Alaskan bush, allowing for less complicated travel. In addition several community members work closely with the YRITWC, collecting water quality samples as part of the YRITWC partnership with the United States Geological Survey (USGS). These unique circumstances facilitated the establishment of relationships with important residents of Saint Mary's, who would later serve as facilitators in the community; which was critical to the success of the study.

Once it was decided to base the study in the city of Saint Mary's, Institutional Review Board clearance was sought and gained from the Colorado Multiple Institutional Review Board at the University of Colorado at Denver (see Appendix D). A letter was then sent to each Tribal government (see Appendix A) introducing the project and the investigator and asking for the permission of the Tribal government to conduct this research in their community. A follow-up phone call was made to the Tribal governments asking for help in recruiting participants for the interviews. This phone call lead to a relationship with the environmental coordinator for the Yupiit of Andreafsky Tribal council, in which he became our guide and facilitator in Saint Mary's and Pitka's Point. At the time, contact with the Algaaciq

Tribal Government was not successful; however a relationship was established at a later date.

Participants were recruited based on the recommendation of our facilitator from the Yupiit of Andreafsky Tribal council who provided a list of names and phone numbers as well as personal introductions with would-be participants. These community members were then contacted for interviews the following week. From there a snowball sampling technique was utilized in which interview participants were asked to recommend other residents they believed would be good interview candidates. Participants were given an information sheet (Appendix B), which informed them of what information gained in the interview would be used for and also explained that the interviews would not be anonymous. A question guide (Appendix C) was developed to focus the interview, but participants were free to guide the interview into areas they felt most important, in their life and community, on the issue of climate change. A total of thirteen interviews were conducted; seven in person in St. Mary's and the adjacent village of Pitka's Point, five over the phone, and one in person at the biennial summit meeting of the YRITWC.

All interviews for this study were conducted from May 2009 to August 2009 all references to interviews in this paper are from this timeframe. Interviews lasted between 30 and 60 minutes and were recorded, in most cases, after the participant had given permission. The interviews were then transcribed and coded for common themes related to climate change issues. Each interview transcription was highlighted when weather, animal, vegetation, or rivers were mentioned by the interview

participant. A table was then made for each interview participant in which salient quotes about the issues of the rivers (Yukon and Andreadsky), the animals, the vegetation and the weather were placed in these tables (Appendix E). These common themes were then related to western scientific knowledge on the issue of climate change in an effort to expand our understanding of the effects of climate change not only in the environment but equally important on the people that live within and are part of that environment.

The following sections will discuss what was learned from the interviews on the issues of climate change. The sections reflect the ways in which climate related issues were discussed by the interview participants: (1) Weather Issues, (2) Animal Issues, (3) Plant Issues, and (4) River Issues.

Findings

Climate Related Weather Issues

Temperature

Yeah, those old people noticed it first. They're not around anymore; they're all under the ground. Yeah, they used to tell me "what's going on with this weather". They noticed. Sometimes it's too hot, sometimes it's too cold.
— Pais Sippary, Resident of Saint Mary's for over 50 years

It is clear from the themes that arose in interviews conducted with Elders and hunters' of the Saint Mary's area that climate change is being felt. Invariably the most common statement made by the thirteen interview participants was that it has gotten warmer in recent years. Temperatures were perceived to be warmer in all

seasons, though most notably in the winter months. In the past winter temperatures reached forty below freezing while today temperatures only reach twenty or thirty below. Moreover in the rare case that temperatures did drop as low as they had historically, it was a brief cold spell, in contrast to the month long cold spells of times past.

Scientific data on air temperature increases in the last 29 years is illustrated in figure 2, which shows that the region surrounding Saint Mary's has experienced a steady average temperature increase of 1.0° Celsius since 1966, as illustrated by the red shading. The scientific evidence supporting a warming climate in the arctic and subarctic regions of Alaska is indisputable (IPCC 2007). However, the increasing body of corroborating IEK is providing a human perspective on a warming climate which includes cultural and socio-economic effects often excluded from scientific environmental climate change studies. This human perspective will be explored more in the following sections.

Weather Patterns

The weather's not predictable like it used to be according to old folks.

-Charlie Prince, Resident of Saint Mary's for over 30 years.

In addition to warmer temperatures the weather was described as being less predictable by the people of Saint Mary's. Pat Beans Jr., a resident of the area of Saint Mary's for 66 years, commented on the unpredictability of the weather:

*h, really unpredictable, you can't plan. You don't know what's
 ig to happen, cause like I said, it will be bad a couple of days then
 r up ya know and you think it's gonna be good it'd be clear for a
 or two and then just right back again. And you don't want to get
 ght out in the county in that weather you know. That was what was
 pening to us, just in and out, constantly three or four months of
 , seems like.*

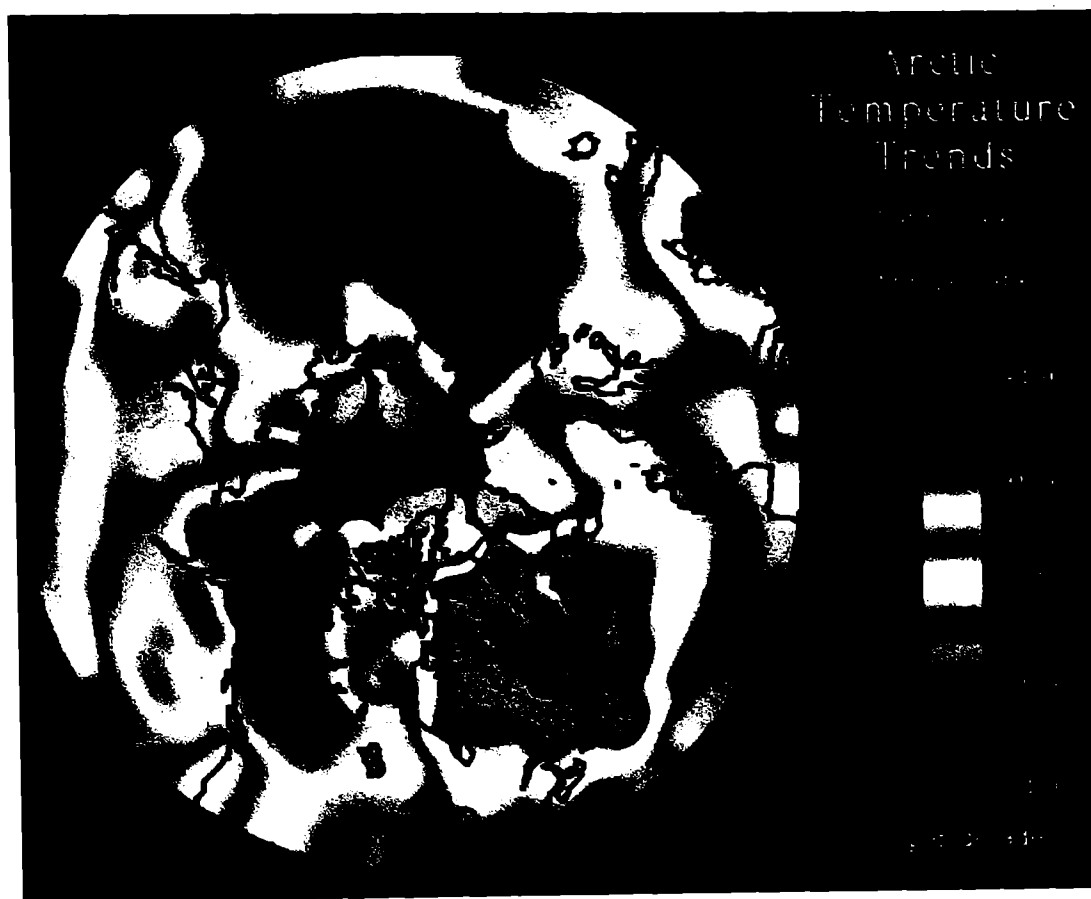


Figure 2 Arctic Temperature Trends 1966-1995 Serreze et al 2000

ents speak to the affect unpredictable weather has on a people relying o
 hunting and gathering way of life. One does not want to “get caught ou
 ry” when the weather suddenly changes. Pat continues.

There's been times where we chat around and say, ya know, this winter's been...really bad, like I said, depressing, you can't plan, can't take a walk ya know or go hunting and feel safe, you know, cause you never know what's gonna happen, this winter was like that. Before this you can kinda plan because it's normally, that's how it works ya know, but this winter was just jumbled up.

Furthermore, the accuracy and skill the Indigenous People once had to predict the weather is less reliable than it once was. As Pat's brother Christopher Beans, also a life-long resident and hunter in Saint Mary's, said "Used to be able to tell, tell the weather by, by the moon or something but now you can't because any kind of weather comes by." Christopher may be speaking of an ability to read the weather by noting the way the moon looks in certain atmospheres and thereby inferring whether a storm is coming. This skill in 'reading' the moon has become less reliable in recent years. Charlie Prince, hunter and resident of Saint Mary's expands on Christopher's point, "I hear stories from the older people that they used to be able to predict the weather longer, longer a week I guess, or so." This change in Indigenous Peoples ability to predict weather has been noted in other Indigenous communities of the north (Fox 2002). Unpredictable weather patterns have also been documented with western scientific methods (Hinzman et al. 2005).

Ursula Prince of Saint Mary's states, "Um, the weather, it seems kinda crazy lately, these past few years, we're either having really dry spells that go on for a long period of time, or with the wet weather, and also...the winter freeze up seems to be a little bit later, and this year our spring break up was a little bit later too." Less predictable and inconsistent weather patterns have numerous implications for the

people. In addition to issues of safety (getting caught out in the country when the weather suddenly turns bad) the patterns of the plants and animals the people depend on may also shift due to shifts in the seasons or the weather, leaving the people to play catch up with Mother Nature. These issues will be explored more in the sections on climate related plant and animal issues.

Precipitation

Changes in precipitation were noted by eight of the thirteen interview participants. Specifically, the month of August was commented on by Charlie Prince, “August is our month that it should be raining all the time and either it comes earlier or it happens later on.” Christopher Beans agreed, “Yeah, usually um, we could get a good rain in August, but we don’t hardly get it anymore.” Furthermore, it was also noted by a majority of the interview participants that there has been a decrease in snow fall in recent years. Bill Alstrom, a Saint Mary’s resident for over 30 years said,

Well, when I first got here in the 1960s, I don’t remember the dates, I was about ten, no I must have been about oh 7 or 8 years old, that’s when I, when we first started living here, and went to school up at the mission. Seems like every year we used to have lots of snow and really cold winters. I used to live down here in that old house, probably the oldest house in Saint Mary’s, right outside our house we’d get a really big snow bank, pretty big snow, kids used to jump off out there, you don’t see that no more.

He continues,

"But gradually...we started noticin'...let's see maybe in the 80s, late 70s, 80s ya know it started... there was this gradual change started, and it seemed like the winters were getting a little warmer, ya know less snow I seen some winters...rain in December and January seems like there's hardly any snow, frozen tundra, ice."

Pat Beans Jr. also commented on the decrease in snow,

"Like I said there used to be a lot of snow, really a lot of snow. This spring, this winter's the first time we had this much snow since, quite some time, I don't know when I can't remember, we had quite a bit of snow. But, all these last few years we haven't had any, hardly any snow."

Scientific climate change research supports the assertion by the people of Saint Mary's that there has been a decrease in the amount of precipitation in the Northern Hemisphere. Groisman et al. (1994) showed, based on satellite images, that mean annual snow cover extent decreased by 10% from the years 1972-1992 in the Northern Hemisphere.

Climate Related Animal Issues

Population Dynamics

Yeah, there's no more ptarmigan, we don't see even the birds like the ducks and geese...especially the ducks you hardly ever see ducks anymore. There isn't that much geese, white geese. And it even seem like the little birds too, summer birds, some of them we don't see any more, it seem like.
- Pat Beans, Resident of Saint Mary's for 66 years.

The general scientific consensus is that climate, forcing changes in weather and rivers, will ultimately manifest in changes to plants and animals. This was found

to be the case in the study area. People spoke of new influxes of species that had not previously been found in the Saint Mary's area as well as a decrease in species that previously were plentiful. Most notably people spoke of a decrease in ptarmigan and other birds and an increase in large mammals such as moose and bears.

When speaking of the changing animal population the interview participants described a concept that everything in Alaska, the seasons and weather as well as plants and animals, moves from the east to the west. People did not seem surprised by the new influx of species that had not been in their area before; instead they seemed to associate it with the natural order of things. In regards to the increase of the beaver population in the Saint Mary's area and the question of whether the population had truly increased or just migrated from other habitats Pat Beans Jr. said,

Well, my dad used to tell us everything moves from east to west. They come down, everything comes down, normally he says if their gonna go extinct or when their gonna finish, that's what happen they start movin' like that ya know, leave nothing behind. And I think that's gonna happen too eventually, cause there was no beaver here before, but there's lots and there's no more up there, and they're all down here they gotta keep going and anything else, he says, like cold weather, fall time, comes from east, upriver interior cold weather come down here, same with the spring, warm weather comes from out east and comes this way, it's the same principle you know.

Pat's brother Christopher echoed this in regards to the increased moose population in their area,

From what I remember, they'd be hardly, you'd be lucky if you went out huntin' and you see maybe eight. And today you can see eight in a bunch. So they're either moving from upriver, movin' on in this way or, the Elders say you know all animals and stuff, ya know, even spring and fall, winter comes from interior and goes down this way. The beaver did the same, they're everywhere.

Research with the Yupiit in Southwestern coastal communities of Alaska found that the people attributed a decrease in the geese (specifically black brant) population to inherent cycles, or to the peoples' lack of attention to how the geese should be treated according to traditional Yup'ik beliefs (Fienup-Riordan, 1999). Traditional Yup'ik beliefs state that animals control their own destinies, when they are treated poorly they will not return, likewise if they are treated properly they return to the hunter year after year (Fienup-Riordan 1999). This theme also arose in interviews with the Yupiit of Saint Mary's. The Elders expressed a belief that animals may be becoming scarce because people were no longer treating them properly. John Thompson, an 86 year old Elder of Saint Mary's stated, "The game is altogether different, we used to make a living catching animals, people don't take care of them like they used to." Sebastian Cowboy, also an Elder of the Saint Mary's village said, "I do believe in native culture, they say that sometime in the future we'll have less, less everything, animals, on the land and in the river too. It's here already." He continues,

Yeah I do believe, I really believe, that native culture they, they've been, they know it from way back a long time ago before everyone was born. Way up north they're getting less moose, they're having a hard time finding moose upriver. Really few. So they're going towards the Bering Sea, it shows that, we're going to have very, very few moose now on the land. When everything, according to the native culture, when animals are gonna to be disappearing, or short, ah very, very little, like jackrabbits, they say many, many years ago, I remember we had lots of jackrabbits when I was growing up, but now there are very few what we got to see in the wintertime. So the world is, ya know, the world is, we're cycling now, cycling.

Population Health

Although throughout the interviews only general questions were asked about the animal populations the issue of the health of the animals was often brought up by the interview participants. The issue of animal health arose particularly in regards to the moose and salmon populations. Ursula Prince, of Saint Mary's, described what she has observed,

I've noticed in the past, well just recently that a lot of our moose meat or fish they begin to show, I don't know what, in the moose meat they look like warts that are in the fatty tissue, and also in the salmon, or the chum or Chinooks, they start to have what look like pus pockets underneath the skin. And that's something really new that I have not seen before um the fact that I've been cutting fish just about my whole life.

This observation of pus pockets on the salmon was stated by other interview participants as well. They may be describing a parasite driven disease called ichthyophoniasis, which was first noticed in Chinook salmon in the YRB in the 1980s (Kocan et. al, 2004). Since first noticed in the 1980's, ichthyophoniasis has become firmly rooted in adult Chinook salmon in the YRB, increasing to levels that impact subsistence and commercial fishing in some areas (Kocan et al, 2004). As Kocan et al. (2004) report, it is unclear whether ichthyophoniasis is a recently introduced pathogen or has been present historically, only now emerging because of changing conditions in the Bering Sea or the Yukon River, or both. Additionally, there was an

estimation that the salmon population had decreased in size and number, which may also be attributed to the disease.

Climate Related Plant Issues

Yeah, it seems like they're (salmon berries) less and smaller.

- Sophie Beans, Resident of Saint Mary's for over 50 years.

The spring that this study was conducted, Saint Mary's had received more snow than it had in years, and all of this snow fell in the early spring which people stated was unusual. Interview participants indicated that salmon berries, an orange berry similar to a raspberry, were becoming more scarce and smaller in size. Pat Beans Jr. stated,

Salmon berries gettin' fewer. That's due to lack of snow. See what's happening is, ya know, after the snow melts right away the tundra dries up. And that's one of the reasons for lack of salmon berries the tundra is drying up and they can't grow when its dry, ya know, that's lack of snow, that's one of the reasons, for lack of salmon berries also.

Towards the end of the summer Ursula Prince was interviewed again at the YRITWC biennial summit meeting and she stated that there had been a lot of salmon berries that year. This seems to support Pat Beans assertion that a lack of snow in recent years had dried out the tundra and caused a decline in salmon berries, while the heavy snows this year had resulted in a large crop of berries. This inconsistency in weather patterns has a direct affect on the people's subsistence. They are unable to know from year to year what the salmon berry crop, or other vegetation they rely on,

will be like. Bill Alstrom spoke of playing catch up with Mother Nature, “Yeah, ya know, the timing is a little off, ya know, them years we used to say, oh it’s going be berry pickin’ season coming up...we go out there and they’re all gone, all dried up, gotta go look elsewhere, ya know, go out on the coast and we could find salmon berries out there.”



Figure 3 Salmon Berries

Additionally, interview participants spoke of changes in the growing season. Scientific research has shown that photosynthetic activity of terrestrial vegetation increased from 1981 to 1994, suggesting an increase in plant growth associated with a lengthening of the active growing season (Myneni et al. 1997). Additionally, this increase was observed to be greatest in the regions between 45° N and 70° N (Myneni, et al. 1997), Saint Mary’s lies at 59° N. The Normalized Difference Vegetation Index

(NDVI) which utilizes satellite images to analyze plant growth, vegetation cover, and biomass production, has also been used to show that both the onset and the length of the growing season has increased North of 45° latitude for the period of 1981-1994 (Holben, 1986; Shabanov et al. 2002). These scientific findings were verified by interview participants in Saint Mary's, Elder, Lena Long, stated: "...trees get green too fast, things growing underground too fast, so fast." She also mentions that there are plants she has never seen before, "But once in awhile we see something it seems like I never see before, leaves some plants growing..." New forms of vegetation were noted by other interview participants as well. Literature published on the movement of plants and animals has been largely theoretical relying on models based on temperature changes. However, the residents of Saint Mary's are noticing changes that could be used to inform models or show that species are in fact moving.

Climate Related River Issues

River Ice

We don't see break up like we used to, the ice isn't solid when it starts breaking up,

its needle ice, [break up] used to be really loud.

- John Riley Sr., Resident of Pitka's Point for 65 years.

In 1995 Ferguson wrote, “There is considerable uncertainty concerning how a warmer climate would affect regional climatic patterns of northern North America.” She predicted however, “Possible impacts include ...altered lake, river, and sea-ice conditions, including early spring breakup, summer reduction, later autumn formation, and reduced winter thickness.”(Ferguson 1995) According to the interview participants in this study, Ferguson’s predictions have become reality. Specifically, all of the thirteen interview participants noted that the ice on the rivers (the Yukon and Andreafsky) has become considerably thinner in recent years, three to four feet thick in contrast to five to six in the past. Christopher Beans spoke of the changes in the ice since he was a child, “It hasn’t been very thick since I was a kid growing up, my dad would set a net in the winter it would go through maybe five, six feet of ice to set net and now maybe you’re lucky if you have three, four feet.” Jay Hootch, a member of the Saint Mary’s village for thirty years, also noted the recent thinning of the ice, “Used to spend the whole day chipping through ice to check fish nets now it only takes an hour.” John Riley a resident of the adjacent village of Pitka’s Point stated in regards to the Yukon River, “Three feet we say is thick now, but it used to be five, six, seven feet thick.”

Although it may sound like thinner river ice benefits the people since they do not have to spend as much time setting or checking their fish nets in the winter, thin river ice has major implications for the people. Thin river ice becomes a socio-economic issue because winter travel is mainly achieved by utilizing the frozen rivers as a transportation route via snow machines or sled dogs. Thinning ice shortens the winter

travel season making it more difficult to trade goods between villages, visit friends and relatives, or reach traditional hunting grounds. Furthermore, it becomes an issue of safety as thin ice makes travel more dangerous.

When asked about open leads, places on the river that remain open and ice free throughout the winter, everyone that had knowledge of the river observed that open leads had increased and leads that had always been open, such as one at the mouth of the Andreafsky River where it meets the Yukon River, have grown in size. An increase in both size and number of open leads is very dangerous for a culture that relies on river ice for transportation throughout much of the year. Often when asked about open leads peoples first response was concerning how many lives had been lost in recent years when someone traveling on the ice by snow machine had fallen in. Lena Long, an 83 year old Yup'ik Elder who has lived in Saint Mary's for over fifty years, expressed her concern about open leads in a phone interview,

Our river goes out to the Yukon not too far about a mile or a little more, and at this mouth this river to the Yukon, it doesn't freeze, it doesn't freeze, people keep drowning there. I don't know how many people now, especially young people. They've been falling in that hole, I don't know how many people now down there. Last year, maybe a couple of years ago, young man and his girlfriend, and this last fall young, a couple of young people not yet twenty both of them fall in...because that place never freezes, we hate, I hate that, other people hate that.

In addition all thirteen interview participants stated that break-up has gotten 'easier' in recent years. People described break-up as being an exciting event in the past, in which people would come down to the shore and watch the crashing of the ice. Today people hardly notice it as more often than not the ice simply melts off.

This loss of break up was attributed to warmer temperatures as well as a lack of water by the people. The ice is thinner because of warmer temperatures, but it also lacks the pressure of high water behind it to cause the ice to break up violently; the flow of the river will be discussed more in the following section.

There was uncertainty about whether or not the timing of break-up has shifted. Some people indicated that break-up was occurring earlier in the spring than it had in the past while others felt that the timing of break-up varies year to year. When asked if the ice breaks up differently than when she was younger, Elder Lena Long stated,

I don't know, I not, I wasn't too sure, maybe I never pay good attention how it is. Yeah I guess it seems like it's getting longer in the spring time, the Yup'ik people, Eskimo people, saying when we have long fall time and it never freezes even it supposed to be freeze then we have a long spring. It's getting like that, it is. It's getting late, later, the break-up, seems like. Every year seems to be because it never freeze on time, like it used to in the fall time, the spring is long. But I know I used to hear since I was little they say, it didn't freeze this fall in the right time it's gonna be a long spring. This year even it's kind of a late break-up.

Lena's statement points to the fact that although people were unsure about whether the timing of break-up has shifted they felt that the timing of freeze had. Hydrologic literature demonstrates that break-up dates have in fact been occurring earlier in the year in certain locations (Brabets, Walvoord 2009). Charlie Prince said, "When the river freezes is getting later and later and almost a month it seems like before it starts freezing up." Interview participants also described changes in the quality of the ice, indicating that the ice is different because it does not freeze and

stay frozen in the fall as it did in the past. Instead the ice freezes and thaws throughout the fall leaving the ice frozen in different layers.

River Flow

Research on stream flow trends in the YRB has shown that contrary to the interview participants' belief that the water is lower, flows have actually increased in the Yukon (Brabets, Walvoord, 2009). Long term stream flow records (>30 years) of the YRB indicate a general upward trend in groundwater contribution to stream flow; it has been proposed that increase in groundwater contributions has been predominately caused by permafrost thawing (Walwood and Striegl 2007). However, earlier spring snowmelt is contributing to a reduced flow in the summer months (Brabets, Walvoord, 2009). This decrease in summer flow may be what the residents of the Saint Mary's area are noticing. Furthermore, Brabets and Walvoord (2009) focused on the Yukon River, whereas the people of Saint Mary's are generally speaking of the Andreafsky. It is possible that the flow may in fact be lower on the Andreafsky year round, as there has been no scientific research on the flows of this river.

Owing to what the participants described as lower spring flows on the Andreafsky and Yukon Rivers the peoples' ability to collect wood has become hampered. In the past the high spring waters that arrived following break-up, allowed people to collect logs flowing down the river to store for the following winters firewood and other projects. In recent years the high waters have not arrived and the wood that does

come down river is trapped in the bushes where the people are unable to get it when the water recedes. Pat Beans relates this situation:

Well, the water being low it makes ah, it affects us quite a bit ah like springtime we count on high water to get ah our logs coming down the river, up the Yukon, collect our wood, for wood come spring ya know, it comes down and then we go out there and collect the wood for wood. We haven't done that, last spring it was a little bit, but water came and then dropped, just dropped and the wood end up back inside the trees and we couldn't get to them. Normally, it stays, high water stays and we can collect all our wood and water start coming down slowly, but not that spring, it just came and dropped down again.

This situation has placed a strain on the heating and building resources of the people. Saint Mary's is located in the tundra where there are no trees to harvest for heating fuel and building materials; they are completely reliant on the high spring waters of the Yukon and Andreafsky Rivers to supply drift wood. Without the seasonal supply of drift wood for heating and other projects they have become more reliant on expensive fossil fuels and in some cases have begun burning woods they otherwise would not, such as cottonwood (personal communication John Riley Sr. 5/2/2008).

In addition to a perception of lower water, many interview participants reported that there has been an increase in sandbars on the Yukon River, shifting the flow of the water. This increase in sandbars may be contributing to the increase in open leads as the sandbars shift the currents of the river creating strong currents that do not allow the water to freeze. As Christopher Beans of Saint Mary's said in regards to the increase in open leads, "It never used to be there [open lead]...Change

in the currents I believe caused that, sandbar building up, current changes. Places that were private fishing grounds, ya know, got eroded. People don't fish there no more." Sergie Nick and John Riley Sr. of Pitka's Point both stated that there had been no sandbars on the Yukon when they were growing up. In the course of the interview, John Riley Sr. pointed to the Yukon River, visible outside the picture window in his living room, and a large sandbar in the middle of the river, which he stated had never been there before. Lena Long, when asked about water levels on the river, stated, "Yes, they hardly any sandbars in the Yukon when I was young. Now sandbars appear everywhere, lots of sandbars...Lots of sandbars."

Although scientific studies have been conducted to measure the sediment load on the Yukon, there is not enough historical scientific data to state whether there has been an increase in sediment load (Dornblaser, Striegl 2009). However, this is exactly the kind of question that IEK can help scientists to answer; the Indigenous Peoples of the Saint Mary's area have been traveling along the Yukon their entire lives as did their parents and grandparents before them. Using a key tool of the scientific method, observation, it is clear that the people of the Saint Mary's area believe sediment loads have either increased or the flow of the river has changed in such a way that sandbars are appearing in places they have not been observed before. This is a great example of the way IEK and Western Science can work together to answer complex questions posed by the uncertainties of climate change.

Conclusion

It is clear from the results discussed above that climate change is being felt in a variety of ways in Saint Mary's and Pitka's Point. Furthermore, these changes are having an impact on peoples' lives ranging from issues of safety to food security. In order to deal with the implications of climate change these issues must be brought to light. It is only through the combined efforts of shared western scientific research and Indigenous Knowledge that strategies may be designed in order to help communities adapt to climate change. In order to be successful in advancing knowledge we must move away from cataloging and documenting and begin with sharing knowledge, of all kinds, across disciplines, class systems, social boundaries and cultures. It is through the sharing of knowledge that real solutions to the complex questions posed by climate change may be answered.

Limitations

This exploratory study was conducted over a five day period in the city of Saint Mary's and the adjacent village of Pitka's Point, Alaska. Time itself was the largest obstacle of this study, building relationships and gaining the trust of community members is critical to the success of this type of research. Our time in the area of Saint Mary's, Alaska was limited by budgetary constraints, which allowed for only one week of travel. Although measures were taken prior to arrival in Saint Mary's to establish relationships with key community members and arrange for interview times, the realities encountered on the ground dictated the number of interviews conducted.

After arriving in Saint Mary's on a Friday morning and meeting with our guide it became clear that contrary to what we were told it would be impossible to conduct interviews over the weekend. Our guide repeatedly reminded us that it was Friday and when introducing us to community members that were potential interview participants never asked the participants if we could contact them over the weekend for an interview, everything was scheduled for the following Monday or Tuesday.

Additionally, once on the ground we were informed that it was the beginning of goose hunting season, a fact that was not relayed to us when arranging the time of our visit over the phone with our guide. This placed another obstacle in our path, as many people were out of the village throughout the week on hunting trips. A longer time frame in which to spend in the village would have allowed for these obstacles to be overcome. In the end thirteen interviews were conducted, which although limited the sample size, did allow for a meaningful understanding of the issues posed by climate change in the community and provided for a solid position from which to begin further work in the YRB.

Of the thirteen interview participants, ten were men. The facilitator recommended mostly men for the interviews, with their wives recommended somewhat as an afterthought. It is unclear whether this was because of paternalistic notions within the culture or that the facilitator felt that men, as hunters and fishermen, would be more knowledgeable about the overall environment. This gender imbalance led to a lack of information about vegetation, as women held most of this knowledge. For instance, when men were asked if they had noticed any

changes in the vegetation, they invariably said they never paid much attention, but when women were asked this same question, they described salmon berry numbers and sizes, how the trees were growing faster, or new vegetation they had noticed growing. In future studies in the YRB steps will be taken to understand the gender roles in each community and ensure an equal, culturally and statistically, representation of male and female participants as the two genders are involved in different subsistence activities and therefore have alternate and complementary observations.

As well as being male most participants were middle-aged, with only three of the interview participants being Elders. Elders are a hard to reach population within these communities as they often do not speak English or do not speak it well. Furthermore, it takes more time to secure the trust of Elders as they are more skeptical of the motives of white researchers than middle-aged community members. One would-be participant spoke of all of the problems that had arisen in the community since they began to speak with the Kusiks (their term for white people) when we were introduced and then declined to be interviewed when they were called at the previously scheduled time. In future efforts, attention will be made to secure a reliable translator that the community members trust so that more interviews can be conducted with participants who are considered Elders by the community. In order to reach the Indigenous Knowledge of a community it is important not only to talk with people who are frequent users of the land, such as hunters and fishers, but also the older generation of land users who remember what their Elders told them about the

land so that this knowledge may be compared with what is readily observable about the environment today. By understanding what the Elders were taught by *their* Elders about the land and comparing this to the knowledge of today's land users a more comprehensive understanding of the ecological and societal changes caused by climate change will be possible.

As stated earlier the biggest obstacle in this study was time, more time in the village as well as more frequent trips to the village will allow for the limitations discussed above to be dealt with. As this was an exploratory study, designed to test the feasibility of a larger study of climate change in the YRB, steps are being taken to design a study that will address these limitations.

CHAPTER 3

FUTURE RESEARCH

Further documentation is highly desirable, both for increasing the understanding of climate dynamics and as a means of engaging arctic residents in the search for appropriate responses to the impacts of climate change. Huntington & Fox 2005

Introduction

Within Alaska, the Yukon River Basin (YRB) is comprised of Cup'ik, Yup'ik, Koyukon and Gwich'in Athabascan Tribal Nations consisting of 62 Tribal communities, over 11% of all Tribes in the entire United States. The overall population of the entire watershed, including Canada, is approximately 110,000 people, with roughly sixty percent of the population Tribal or First Nation citizens. The Yukon River and surrounding lands provide over fifty percent of the Indigenous peoples' sustenance in the form of fish, moose, caribou, berries, mountain sheep, rabbit, beaver, duck, goose and other animals; making sustainable management and appropriately implemented adaptation strategies in the face of a changing climate exceedingly important. The YRB is roughly twice the size of California, however Tribal lands only include an area roughly the size of Delaware. Regardless of land ownership, the effects of climate change are indiscriminant in terms of political boundaries. The entire YRB terrestrial system, whether it is Tribal, federal, or state lands, will be affected by the increasingly warming climate.

The arctic and subarctic has been called the canary in the coalmine of climate change by many scientists. Northern regimes are experiencing accelerated warming relative to middle and low latitudes (Hinzman, 2005). Understanding the changes that are taking place in the YRB will allow not only for adaptation strategies to be developed that will allow the Indigenous Peoples of the YRB to continue to subsist in their traditional manner, but also the development for models that may aid in the understanding of how climate change will affect other parts of the world. Climate change will disproportionately affect the nations of the developing world on a larger scale than the developed world. These nations continue to subsist on the land as do those in arctic and subarctic. The knowledge gained from adaptive strategies presently developed and tested in the north will facilitate the transmission of ideas to people in other parts of the world that may need to respond to climate change in the near future.

The Watershed Council and the USGS

The Yukon River Basin Project, a United States Geological Survey (USGS) multi-disciplinary project, began in 2001 with two objectives: 1) establish a water quality baseline for the Yukon River and its major tributaries against which to measure impacts from climate change, and 2) utilizing baseline and on-going collection of process study-based data, develop a better understanding of ecosystem response to climate change. The completion of these objectives will enable better management natural resources which will ultimately help to sustain the cultural resources of the Indigenous Peoples of both current and future generations.

In 2004 a partnership was formed between the USGS and the Yukon River Inter-Tribal Watershed Council (YRITWC) fostering the development of their water quality program as well as the continuation of the USGS YRB project. This joint effort continues to develop as a truly collaborative endeavor and four successful years of water quality research have been completed. This relationship has been growing since its inception and in 2009 was cemented with the signing of a Memorandum of Understanding (MOU) between the USGS and the YRITWC, signed by the then acting director of the USGS, Suzette Kimball, and the executive board members of the YRITWC from the United States and Canada at the seventh Biennial Summit Meeting of the YRITWC in Whitehorse, Yukon Territory, Canada.

The YRITWC is governed by the largest international treaty between Indigenous governments in the world; 70 of the 76 Tribes and First Nations of the YRB participate in the watershed council through the enactment of an Inter-Tribal Accord. Currently, the YRITWC Science Department operates and maintains the largest Indigenous Observation Network (ION) in the world. The network currently includes a water quality study that maintains 39 sampling sites throughout the YRB and a soil Active Layer Network (ALN) study, in which depth to permafrost is measured at 12 sites. Combined, these involve over 30 local volunteer technicians and 23 Indigenous governments across the basin.



Figure 1 Signing of the MOU in Whitehorse, Yukon Territory, Canada August 2009

In addition to the water samples collected throughout the year by local volunteer technicians, in 2007 the YRITWC science team and local volunteers began taking a "Healing Journey" down the river each summer. The Healing Journey has been a way to an entirely new level of cohesion in river ecology studies and water quality data collection. To overcome some of the challenge of testing water quality in river systems, without interference from motor exhaust or propeller cavitations, YRITWC uses canoes to travel close to the flow of the river and measure real changes in water-quality using a multi-probe sensor. Measurements of five

or quality parameters (Dissolved Oxygen, Temperature, Specific Conductance, and Nitrate) are taken every five minutes and the data is stored along with GPS coordinates, providing a chemical profile of the entire Yukon River as it travels through different eco-regions, landscapes, and land uses. The USGS has facilitated processing of samples collected on the Healing Journeys and the compiling of the data.



Figure 2 Community volunteers collecting water samples on the Yukon River

The Healing Journey forms a unique connection between the people and the science of the River, and have become a foundation toward pursuing three central goals: (1) to spread messages of environmental stewardship to youth and communities along the rivers traveled, (2) to learn the Knowledge of Indigenous peoples of the rivers, and (3) to collect and process scientific data to create a real-time database for the entire river system, which empowers the people for inclusion in decision-making processes for managing resources.

The interdependence of local Tribal governments, YRITWC, the USGS and the Yukon Territory Government (YTG) is a unique relationship. The data collection network empowers local communities, creates stability through standardization, and uses scientific rigor for comparability and reproducibility across space and time. The success of this community-based science approach emphasizes the important role that people play in the environment.

This relationship between the YRITWC and USGS facilitated the previously discussed project in the Saint Mary's area. As of November 2009, the USGS and the YRITWC with the collaboration of researchers from Colorado State University (CSU) and the National Forestry Service (NFS) began the development of a proposal for submission to the National Science Foundation (NSF). This project will expand upon the previous study in Saint Mary's as well as add a new component of snow measurement to the YRITWC/USGS water quality program. This project will address the limitations that were discussed in relation to the Saint Mary's project and

seek to develop adaptation strategies to help YRB communities deal with a changing climate through Community Based Participatory Action Research (CBPR) within a socio-ecological framework.

Uniting Community and Through Science and Indigenous Knowledge: Strategic Needs on Water in the Yukon (SNOWY)

The baseline data set that has been, and continues to be, developed by YRITWC/USGS partnership is only a portion of the climate change story in the YRB. Previously hydrologists believed that hydrological systems shut down during the long, cold, Alaskan winter. It has become evident that this is not the case; the hydrologic system continues to operate under the frozen ground and rivers, as well in the form of winter precipitation and a dynamic snowpack (Freeze & Cherry 1979). Neglect of seasonality in previous studies has provided a gap that can be filled using the YRITWC Indigenous Observation Network and a point from which a qualitative study to further understand climate change can begin. The goal of the baseline dataset is to capture a holistic view of the YRB system, with the best information possible. Logically, the next step is to pursue a direction that allows for the exploration of the year-round dynamics of the basin, utilizing both western scientific methods and documenting Indigenous Environmental Knowledge (IEK).

Historically, sampling during the winter has been sporadic and neglected in the past by both the YRITWC and the USGS due to the logistical difficulties presented by the winter season. Thus, snow dynamics will be focused on heavily during the

winter months of this project complemented with summer synoptic river studies, facilitating a means to engage with community members with qualitative methods. The following sections will discuss the theoretical background of this proposed project and outline the methods that will be utilized in order to reach the goal of better understanding climate change in the YRB to facilitate the development of adaptation strategies to help YRB communities cope with these changes and add a winter snowpack sampling component to the YRITWC science departments water quality program.

The Socio-Ecological Cycle

The Socio-Ecological cycle highlights the important role humans play in the environment by connecting their social activities around the environment with the physical ecological cycle (Figure 3). The founding vision of the YRITWC is to restore, protect and preserve the River for future generations. In order to carry out this vision in the execution of this project, the goal is to re-engage humans with the environment and empower the Indigenous Peoples of the YRB to take ownership of their surroundings through Community Participatory Research.

Community Based Participatory Research

Community Based Participatory Research (CBPR) also known as, community based action research, community participatory action research, or several other similar names, is an orientation more than it is a specific methodology. It is a theoretical orientation that is guided by a belief in the democratization of knowledge

production and use, ethical fairness in the benefits of the knowledge generation process, an ecological stance toward society and nature, and an appreciation of the capacity of humans to reflect, learn, and change. With these beliefs guiding research CBPR becomes a tool for working with people to solve problems. CBPR is different from traditional research frameworks in that it approaches solving a problem by involving the people affected by the problem in developing the solutions through collaborative research, planned action, and process and outcome evaluation. This project will utilize CBPR in order to understand what problems are being posed by climate change in each respective community and what solutions the community has for overcoming these problems. In order to understand how climate change may be altering the environment and how this is affecting the people, the investigators will engage with community members and seek to understand the Indigenous Knowledge that guides the peoples relationship with the environment and how this knowledge is relevant in understanding climate change and overcoming the challenges presented by climate change.

In arguing for a “turn” in the social sciences away from positivism and towards action research, Reason and Torbert (2001) state, “...whereas the primary purpose of research in the academic tradition to is contribute to an abstract “body of knowledge” available to third-party persons, the primary purpose of research/practice after the action turn is a *practical knowing* embodied in the moment-to-moment action of each research/practitioner, in the service of human flourishing and the flourishing of the eco-systems of which we are a part.” The proposed research project in the YRB will

embody this principle. Instead of collecting Indigenous Knowledge with the goal of cataloging it, the knowledge will be used by the researchers and participants alike to design and implement adaptation strategies which allow as Reason puts it, "...human flourishing and the flourishing of the eco-systems of which we are a part."

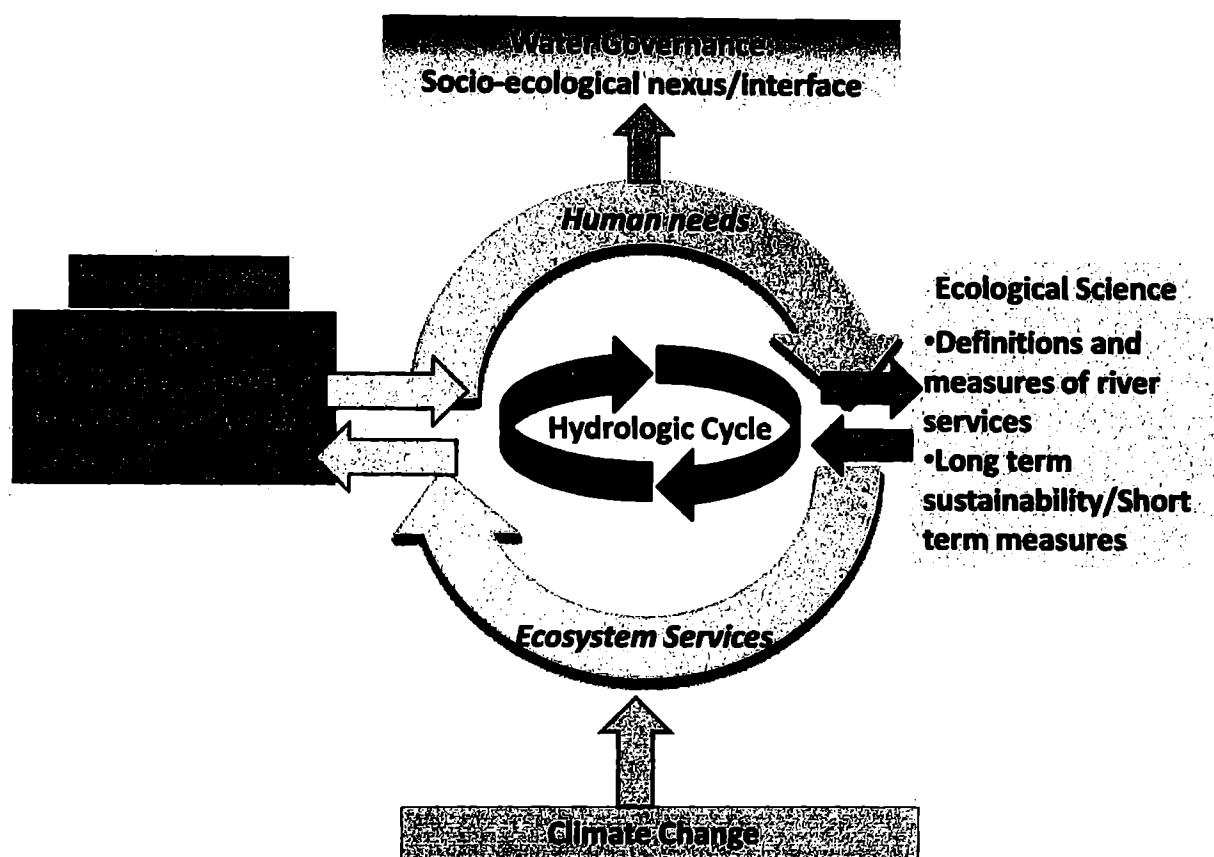


Figure 6 Humans in the Socio-Ecological Cycle

A research paradigm of this nature is a perfect fit for a project in the YRB. In order to understand and solve the problems posed in each YRB community by climate change the people must buy into the process and take ownership of the

solutions. Because of the relationship YRB communities share with the YRITWC and the USGS, by virtue of their participation in the water quality observation network, a relationship of trust in a shared future has been forged. This relationship of trust will allow for a new project revolving around a snow observation network to take root and thrive in these communities. Through training and participation in the monitoring of winter precipitation, the people will take ownership of the science of their watershed, and through this participation discussions can begin to take place that will allow for the transmission of knowledge from the Indigenous residents to the scientists as well as from the scientists to the Indigenous residents.

This transmission of knowledge between scientists and local technicians will lay the foundation for qualitative methods that reach out to the rest of the community members through focus groups and in-depth interviews. This will allow for a deeper understanding of what challenges people are facing, in each season, due to climate change and what solutions are available to them to overcome these challenges. Furthermore, by understanding how the people themselves view their relationship with the land and discussing their problems with them, they themselves can come up the solutions and the YRITWC and USGS can aid them in implementation and evaluation.

Research Questions – Hypotheses

This research project attempts to look at many aspects of climate change through community participatory research in which the community members are both

taking part in the collection of scientific data as well as sharing their Indigenous Knowledge of the environment to answer questions central to a greater understanding of climate change in the subarctic. Because the proposed project has a qualitative and quantitative component there are research questions that correspond to the qualitative side and hypotheses the research seeks to answer quantitatively. For organizational purposes the research questions/hypotheses are divided into groups based on the kind of information/data is sought, but many of the research questions and hypotheses form an interrelated web as opposed to the linear form displayed below (Table 1).

Each research question and hypotheses will have its own set of methodology to answer the question or prove the hypothesis. The qualitative research questions will be answered through surveys, focus groups, and in-depth interviews with Elders and land users of each community. The quantitative hypotheses will be tested through the collection of water quality data, permafrost data, and snow measurements/data collection. As discussed above the USGS and YRITWC are already collecting data on water quality and permafrost and this will continue with the implementation of this project. However, the conclusions sought about water quality and permafrost likely will not be answered within the timeframe proposed for this new project as it takes years of baseline data to answer questions as big as climate change. However, this project will add a winter precipitation component to the water quality program that will further facilitate a large baseline dataset for future use.

Table 1 Research Questions and Hypotheses

Qualitative	Quantitative
Water Quality	Water Quality
Are water quality changes affecting human and food source populations?	Healing Journey: Water Quality profiles on YR change through space & Time with land cover and climate
Are water quality changes driven by land cover and climate change affecting human and food source populations?	Station Data: Water Quality measured at fixed stations changes over space and time in the YRB
Water Quantity	Water Quantity
What affect do changing flow regimes (seasonal and annual) have on communities, resources and economics?	Based on long-term USGS gauging and in-situ discharge measurements flow regimes in the YRB are changing.
Snow	Snow
How does changing snow cover change local way of life?	Snow cover is changing through time and over space as driven by climate change
Permafrost	Permafrost
How are changes in permafrost affecting community infrastructure transportation and land cover?	Active layer depth and permafrost thaw are increasing due to climate change.

Methods

In order to build upon the already extensive Indigenous Observation Network (ION), a snow measurement/data collection program will be designed using the ION model and will produce a holistic year-round data collection program by expanding the existing water quality program into the winter months. The purpose is to engage

the people who have experience with the “story” of the snow and water, in terms of Indigenous Knowledge and observations of the environment, and compliment that knowledge with expertise of the hydrological sciences. With this approach the communities become the mechanism through which a more holistic data set is collected both by engaging in winter water quality data collection as well as engaging in discussions of what they already know about winter precipitation. The qualitative component of this project will center on focus groups held with Elders and land users in the community in which issues relevant to climate change are identified as well as corresponding adaptation strategies that are socially and ecological appropriate in each community.

The design of this project revolves around a winter Healing Journey that will take place in the March 2011 in the lower section of the YRB to complement the Healing Journey already in the planning stages by the YRITWC that will take place in the summer of 2011. Traveling along the river, by canoe during the summer and by dog team or snow machine in the winter, allows for a means of creating a “buzz” and will facilitate an interest in the project within the community. Logistically, it would be difficult to stop in each village in lower-river, especially in the winter; instead hub villages will be chosen. In this scenario, members of nearby villages will be invited to the hub village to participate and some key community members will be brought in from nearby villages by the researchers. The winter Healing Journey will begin at Russian Mission and end at Chevak, with stops to three hub communities: Marshall, Emmonak, and Chevak (see Figure 4). These communities were chosen because they

already have existing sites with grids for snow measurements to be taken as they are participating in the Active Layer Network permafrost monitoring study. The winter Healing Journey will take a month to complete allowing for a week to be spent in each hub community.

The Healing Journey will become the mechanism through which communities are reached in order to participate in the snow measurement/data collection as well as focus groups. However, Tribal councils and other key community members will be contacted early in the Healing Journey planning stages to ensure the community's willingness to participate. Additionally, a survey will be conducted by investigators prior to the winter Healing Journey in which participants are asked questions to ascertain what issues are salient in that community in regards to climate change and are invited to participate in a mapping exercise. Communities will be visited again after the winter Healing Journey for more in-depth interviews.

When stopping in a hub community during the winter Healing Journey the visit will begin with a community meeting in which volunteers are recruited for trainings and focus groups and scientific data collected in the previous field season is presented. These community meetings will serve two purposes: (1) they will provide a much needed check to ensure that the investigators heard what the people were saying when the surveys were conducted and get everyone ready to participate in focus groups; (2) they will provide a means of getting the results of the information collected by the community, by means of water and snow sampling, back to the

community, allowing for the community to understand the benefit of their work and take ownership of the science they are conducting. Moreover, while the investigators present the scientific work being done in the region “next-step” ideas can be presented allowing for the community to give input on what science issues they would like to YRITWC tackle in the future.

The winter Healing Journey will be conducted in March and April at the average time of maximum snow depth in this region. By reaching the communities at the maximum depth of snow fall a yearly sample/measurement of snow dynamics can be made by the scientists traveling with the Healing Journey. Additionally, a workshop will be conducted in a hub community to facilitate hands on training on collecting snow measurements. The training will help identify dedicated technicians in each community who will carry out data collection throughout the year. As a specific example, a community member will be identified who will be responsible for carrying out a synoptic daily snow measurement. This synoptic snow measurement will provide valuable scientific data while building local capacity and linking existing local knowledge of snow with the technical properties of snow.

While in the community during the winter Healing Journey, the other investigators will conduct focus groups with Elders and land users in the community. These focus groups will seek to further understand the problems being posed by climate change in the community. Additionally, the investigators wish to learn from the Indigenous Knowledge these community members hold on snow. This

knowledge will complement the scientific data being collected in the community and allow for a deeper understanding of what affect snow dynamics has on the people. Several focus groups will be conducted, some utilizing participatory mapping techniques and some utilizing brainstorming techniques to come up with solutions for problems brought about by climate change.

Focus groups are an ideal way of interacting with the villages in the YRB for several reasons. First of all focus groups are a culturally appropriate mode of gaining information in indigenous communities because of the communal nature of the society. Also, group interviews are useful for generating hypotheses based on participants' insights and developing questions for more in-depth individual interviews later on. In this case hypotheses will be generated in the focus groups about what can be done to adapt to the changes happening in their community. Finally, focus groups are an appropriate way to carry out a CBPR project because it allows for the most people in the community to be brought into the project in the least amount of time.

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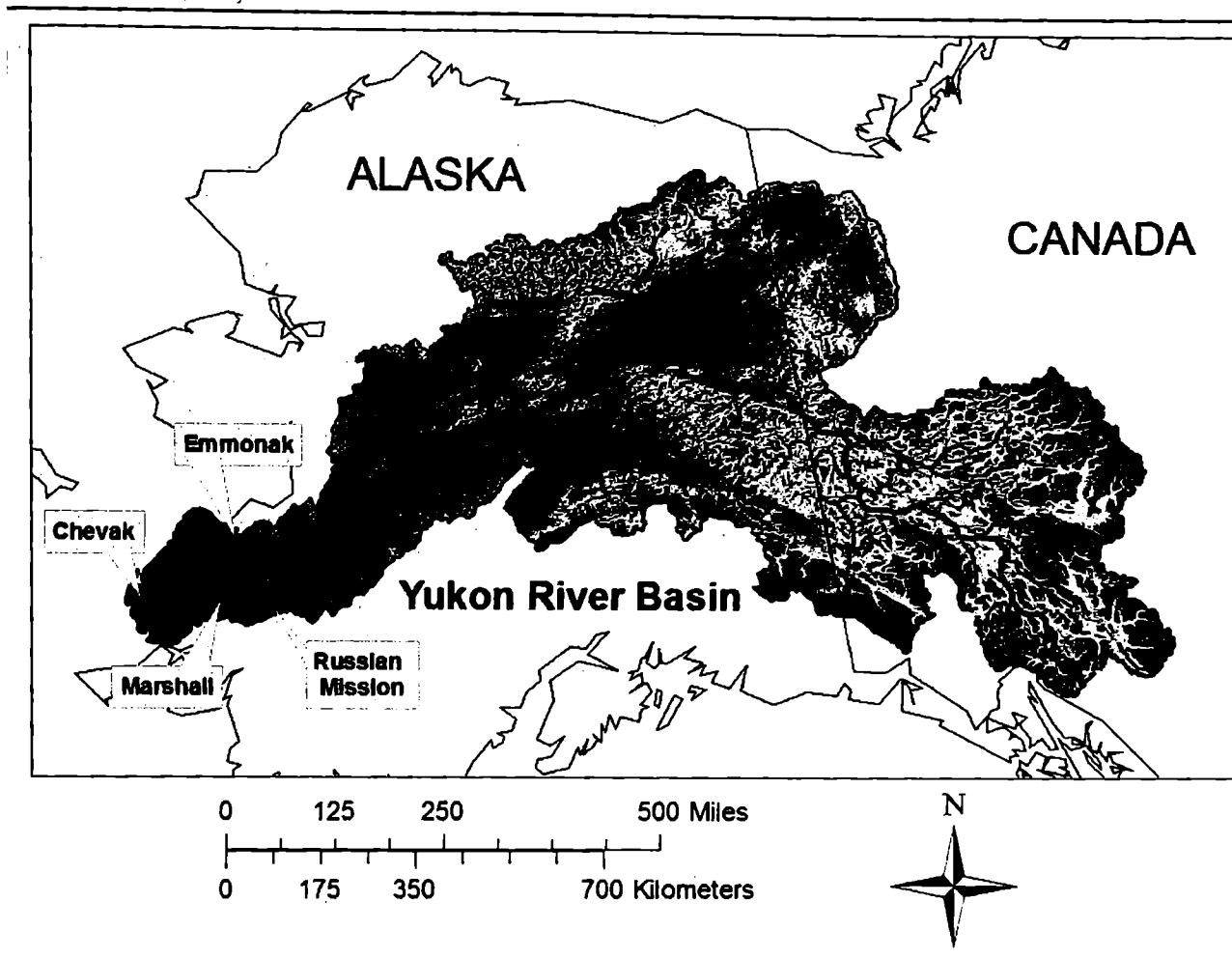


Figure 7 Hub communities to be targeted in the winter Healing Journey

Conclusion

Climate change is a real issue facing the land and people of the Arctic/Sub-
 arctic, which demands a creative approach to study and facilitate the transfer of
 information for better decision-making strategies. The goal of this research is to
 bring together scientists and community in order to develop a greater understanding
 of how climate change is having on the Indigenous Peoples and the ecology of
 the Lower Yukon River Basin (YRB). The project plan will be implemented through

identification of community-driven science questions, data collection and engagement between scientists and community members to facilitate the development of adaptive strategies for communities within the YRB. This participatory approach builds upon the long-term observations of the Indigenous community, complemented by scientific data collection, to address locally relevant scientific questions. The synergy between groups will provide a framework to address human needs, ecosystem services, and greater environmental understanding in the basin. In addition, the method will leverage existing resources with the aim to create new resources to address climate change issues currently and imminently facing the people of these regions.

APPENDIX A

LETTER TO TRIBAL GOVERNMENT

March 26, 2009

Yupit of Andreafski Tribal Council
P.O. Box 368
Saint Mary's, AK 99658

Yupit of Andreafski Tribal Council,

My name is Nicole Herman-Mercer and I am a graduate student currently interning at the United States Geological Survey (USGS) in Boulder, Colorado. My supervisor, Paul Schuster, and I would like to conduct a research project in the city of Saint Mary's in order to understand indigenous perspectives of climate change. Paul Schuster is a hydrologist and he has been working with the Yukon River Inter Tribal Watershed Council (YRITWC) to collect water quality data on the Yukon River for the past eight years. We have been working in association with Bryan Maracle of the YRITWC to develop this research project.

We are contacting you to ask for your permission and help in conducting research in your community. Our goal is to document how changes in the environment have affected the people in the Yukon Watershed. Our aim is to use this information to inform and direct western science on areas that are in need of more intense investigation. To do this we would like to interview long time residents of Saint Mary's in order to gain an understanding of the local ecology as experienced by its people.

Our hope is that through this study we can demonstrate the need for documentation of indigenous knowledge of the environment to foster a greater understanding of our changing climate and a greater voice for indigenous communities in drafting policy on this issue that is quickly affecting the way we all live. All the information gathered through interviews will be made available to the tribe for use as you see fit and we are open to facilitating the needs of the tribe in this area. The results of this study will be used to complete a master's thesis for the University of Colorado at Denver; they may also be used for publication in scientific journals which will be available to the public. I will follow up this letter with a phone call in the coming weeks, if you would like to reach me sooner, please feel free to call or email me. I look forward to working with you.

Respectfully,

Nicole Herman-Mercer
USGS, BRR
720-233-5885
nhmerc@usgs.gov

nhm

APPENDIX B
INFORMATION SHEET

Date: April 30, 2009

**Study Title: Indigenous Perspectives of Climate Change in the Lower Yukon River
Basin, Alaska**

Principal Investigator: Nicole Herman-Mercer

HSRC #: 09-0141

You are being asked to be in a research study. This form provides you with information about the study. A member of the research team will describe this study to you and answer all of your questions. Please read the information below and ask questions about anything you don't understand before deciding whether or not to take part.

This study plans to learn more about how indigenous residents of Saint Mary's, Alaska perceive climate change and what effects the changing climate has on their lives. Our goal is to combine this indigenous knowledge of climate change in the North with western scientific knowledge on the issue of climate change.

You are being asked to be in this research study because you are a long time indigenous resident of the area who has been recommended by the tribal council or others who have already participated in this study.

Up to twenty people will participate in the study.

If you join the study you will participate in a semi-structured interview about your environmental knowledge of the area lasting anywhere from thirty to ninety minutes.

This study is being paid for by a department of the United States Geological Survey (USGS), titled Student Interns in Support of Native American Relations (SISNAR).

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you choose to take part, you have the right to stop at any time. If you refuse or decide to withdraw later, you will not lose any benefits or rights to which you are entitled.

The researcher carrying out this study is Nicole Herman-Mercer. You may ask any questions you have now. If you have questions later, you may call Nicole at 720-233-5885.

You may have questions about your rights as someone in this study. You can call Nicole Herman-Mercer with questions. You can also call the Human Subject Research Committee (HSRC). You can call them at 303-315-2732

APPENDIX C

QUESTION GUIDE

- How long have you and your family lived in Saint Mary's?
- Can you tell me about some of the things you do in each season?
 - Have these things changed since you were a child?
- Can you tell me about any major changes that you have seen in the climate?
 - Changes in weather patterns?
 - Changes in vegetation?
 - Changes in water levels?
 - Changes in the animals?
- Do other people in the community notice the changes you just mentioned?
- How have these changes affected you and people you know?
 - Have you changed anything you do because of these changes?
- What is the one most important issue facing your community because of climate change?
 - Why?
- Can you tell me about holes in the ice that remain open through the winter in the Yukon River in or around Saint Mary's?
 - Has this changed in recent years? From year to year or throughout the season?
- Do you know where these holes are?

- Have you noticed a difference in the thickness of the ice before ice break-up (late March to Early April)?
- Have you noticed a difference in how quickly the ice breaks up?
 - What about in the way the ice breaks up (violent vs. calm)?
- Can you tell me what you know about flooding events on the Yukon River in and around your community?
 - Have you noticed changes in the timing of flooding (early vs. late season)?
 - How long has this flooding lasted?
 - Has there been a change in the severity of flooding events?
 - Have you noticed changes in the frequency of flooding?
 - What do you attribute these changes to?
- What type of changes to the land and animals does flooding cause?
 - Does it destroy the current plants and animals habitat/territory or create habitat? THESE QUESTIONS DEPEND ON THE ANSWER TO PREVIOUS FLOODING QUESTIONS
- Can you tell me about the beaver population in your area?
- Has the population increased or decreased?
 - Can you give me an idea of how much the population has increased or decreased?
 - How has this increase/decrease changed the land?

- Where is the beaver population?
- Why do you think the beaver population is changing?
- Can you recommend any elders that would be willing to discuss these same kinds of things with me?

APPENDIX D

HUMAN SUBJECTS APPROVAL



Colorado Multiple Institutional Review Board
13001 E. 17th Place
Building 300, Room N3214
Aurora, Colorado 80010-7238

System Address:
Mail Stop F-490
P.O. Box 6508
Aurora, Co 80045-6508

303 724 1055 (Phone)
303 724 0990 (Fax)
uchsc.edu/comirb (Web)
comirb@uchsc.edu (E-Mail)
FWA00005070 (FWA)

University of Colorado Hospital
Denver Health Medical Center
Veterans Administration Medical Center
The Children's Hospital
University of Colorado Denver
Colorado Prevention Center

Certificate of Exemption

23-Mar-2009

Investigator: Nicole Herman-Mercer
Sponsor(s):
Subject: COMIRB Protocol 09-0141 Initial Application
Effective Date: 23-Mar-2009
Anticipated Completion Date: 31-Oct-2009
Exempt Category: 2
Title: Indigenous Perspectives of Climate Change in the Yukon River Valley, Alaska

This protocol qualifies for exempt status. Periodic continuing review is not required. For the duration of your protocol, any change in the experimental design/content of this study must be approved by the COMIRB before implementation of the changes.

The anticipated completion date of this protocol is 31-Oct-2009. COMIRB will administratively close this project on this date unless otherwise instructed either by correspondence, telephone or e-mail to COMIRB@uchsc.edu. If the project is closed prior to this date, please notify the COMIRB office in writing or by e-mail once the project has been closed.

You will be contacted every 3 years for a status report on this project.

Any questions regarding the COMIRB action of this study should be referred to the COMIRB staff at 303-724-1055 or UCHSC Box F-490.

Sincerely,

UCD Panel S

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